

IN THE CLAIMS:

1. (Currently Amended) A driver circuit for driving a permanent-magnet electric motor, comprising:

an inverter for generating an electric current to be applied to the permanent-magnet motor, according to a commanded voltage value applied thereto;

a motor-drive-current detector operable to detect the drive current of the motor;

a current detector operable to detect a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current; and

a controller operable to calculate a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value, said controller being further operable to calculate a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor, and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage, said controller controlling said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed, wherein said controller generates a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, based on factors including an inductance of the motor and an electric resistance of the motor, wherein said factors further include an angular velocity of the motor.

2. (Canceled)

3. (Previously Presented) A driver circuit for driving a permanent-magnet electric motor, comprising:

an inverter for generating an electric current to be applied to the permanent-magnet motor, according to a commanded voltage value applied thereto;

a motor-drive-current detector operable to detect the drive current of the motor;

a current detector operable to detect a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current; and

a controller operable to calculate a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value, said controller being further operable to calculate a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor, and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage, said controller controlling said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed, wherein said controller is operable for calculating said d-axis difference signal and said q-axis difference signal in a low frequency range, said controller controlling said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed, and said controller generates a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R & \omega L_q \\ -\omega L_d & R \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value,

i_{qr} is said commanded q-axis current value,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor, and

ω is an angular velocity of a rotor of the motor.

4. (Canceled)

5. (Previously Presented) A driver circuit for driving a permanent-magnet electric motor, by comprising:

an inverter for generating an electric current to be applied to the motor, according to a commanded voltage value applied thereto;

a motor-drive-current detector operable to detect a drive current of the motor;

a current detector operable to detect a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current;

a current-difference calculator operable to calculate a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value;

a non-interference processor operable to calculate a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor, and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage; and

an inverter controller operable to control said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed,

wherein that said non-interference processor generates a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R - \omega L_d & -\omega L_q \\ \omega L_d & R - \omega L_q \end{pmatrix} \begin{pmatrix} j d \\ j q \end{pmatrix} + \begin{pmatrix} \omega L_d & 0 \\ 0 & \omega L_q \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

$$\frac{d}{dt} \begin{pmatrix} j d \\ j q \end{pmatrix} = \begin{pmatrix} -\omega d & 0 \\ 0 & -\omega d \end{pmatrix} \begin{pmatrix} j d \\ j q \end{pmatrix} + \begin{pmatrix} \omega d & 0 \\ 0 & \omega d \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value,

i_{qr} is said commanded q-axis current value,

v_d is a d-axis voltage applied to the motor,

v_q is a q-axis voltage applied to the motor,
 L_d is an inductance of the d-axis of the motor,
 L_q is an inductance of the q-axis of the motor,
 R is an electric resistance of the motor,
 ω is an angular velocity of a rotor of the motor,
 Φ is a number of magnetic cross fluxes of the permanent magnet,
 j_d is a d-axis state quantity of said non-interference processor,
 j_q is a q-axis state quantity of said non-interference processor, and
 ω_d is a coefficient.

6. (Canceled)

7. (Previously Presented) A driver circuit according to claim 5, wherein that said non-interference processor is operable on the basis of the calculated d-axis and q-axis current differences, for calculating said d-axis difference signal and said q-axis difference signal in a low frequency range.

8. (Previously Presented) A driver circuit for driving a permanent-magnet electric motor, by comprising:

an inverter for generating an electric current to be applied to the motor, according to a commanded voltage value applied thereto;

a motor-drive-current detector operable to detect a drive current of the motor;

a current detector operable to detect a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current;

a current-difference calculator operable to calculate a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value;

a non-interference processor operable to calculate a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor, and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage; and

an inverter controller operable to control said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed, wherein that said non-interference processor generates a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R & \omega L_q \\ -\omega L_d & R \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value, i_{qr} is said commanded q-axis current value,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor.

9. (Previously Presented) A driver circuit for driving a permanent-magnet electric motor, comprising:

an inverter for generating an electric current to be applied to the permanent-magnet motor, according to a commanded voltage value applied thereto;

motor-drive-current detecting means for detecting the drive current of the motor;

current detecting means for detecting a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current;

current-difference calculating means for calculating a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value;

non-interference processing means for calculating a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor, and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage; and

inverter control means for controlling said inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed, wherein that said non-interference processing means generates a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R & \omega L_q \\ -\omega L_d & R \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value, i_{qr} is said commanded q-axis current value,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor.

10. (Previously Presented) A method of controlling a driver circuit for driving an electric motor, comprising the steps of:

detecting a drive current of the motor;

detecting a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current;

calculating a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value;

calculating a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor and a q-axis difference signal

which is a function of the q-axis input voltage and is not a function of the d-axis input voltage;
and

controlling an inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed, wherein said step of calculating a d-axis difference signal and a q-axis difference signal comprises calculating a value xd as said d-axis difference signal, and a value xq as said q-axis difference signal, according to the following equation:

$$\begin{pmatrix} xd \\ xq \end{pmatrix} = \begin{pmatrix} R - \omega L_d & -\omega L_q \\ \omega L_d & R - \omega L_q \end{pmatrix} \begin{pmatrix} jd \\ jq \end{pmatrix} + \begin{pmatrix} \omega L_d & 0 \\ 0 & \omega L_q \end{pmatrix} \begin{pmatrix} idr - id \\ iqr - iq \end{pmatrix}$$

$$\frac{d}{dt} \begin{pmatrix} jd \\ jq \end{pmatrix} = \begin{pmatrix} -\omega d & 0 \\ 0 & -\omega d \end{pmatrix} \begin{pmatrix} jd \\ jq \end{pmatrix} + \begin{pmatrix} \omega d & 0 \\ 0 & \omega d \end{pmatrix} \begin{pmatrix} idr - id \\ iqr - iq \end{pmatrix}$$

wherein id is said d-axis current,

iq is said q-axis current,

idr is said commanded d-axis current value,

iqr is said commanded q-axis current value,

vd is a d-axis voltage (actually applied to the motor),

vq is a q-axis voltage (actually applied to the motor),

Ld is an inductance of the d-axis of the motor,

Lq is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor,

Φ is a number of magnetic cross fluxes of the permanent magnet,

jd is a d-axis state quantity,

jq is a q-axis state quantity, and

ωd is a coefficient.

11. (Canceled)

12. (Previously Presented) A method according to claim 10, wherein said step of calculating a d-axis difference signal and a q-axis difference signal comprises calculating, on the

basis of the calculated d-axis and q-axis current differences, said d-axis difference signal and said q-axis difference signal in a low frequency range.

13. (Previously Presented) A method of controlling a driver circuit for driving an electric motor, comprising the steps of:

detecting a drive current of the motor;

detecting a d-axis current and a q-axis current which are respectively an exciting current component and a torque current component of the detected drive current;

calculating a d-axis current difference between the detected d-axis current and a commanded d-axis current value, and a q-axis current difference between the detected q-axis current and a commanded q-axis current value;

calculating a d-axis difference signal which is a function of a d-axis input voltage of the motor and is not a function of a q-axis input voltage of the motor and a q-axis difference signal which is a function of the q-axis input voltage and is not a function of the d-axis input voltage; and

controlling an inverter on the basis of the calculated d-axis and q-axis difference signals, such that the d-axis and q-axis difference signals are zeroed, wherein said step of calculating a d-axis difference signal and a q-axis difference signal comprises calculating a value x_d as said d-axis difference signal, and a value x_q as said q-axis difference signal, according to the following equation:

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \begin{pmatrix} R & \omega L_q \\ -\omega L_d & R \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value,

i_{qr} is said commanded q-axis current value,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor, and

ω is an angular velocity of a rotor of the motor.

14. (Currently Amended) A driver circuit according to claim 2 1, wherein the values x_d and x_q being represented by the following equation:

$$\begin{pmatrix} \dot{x}_d \\ \dot{x}_q \end{pmatrix} = \begin{pmatrix} R - \omega L_d & -\omega L_q \\ \omega L_d & R - \omega L_q \end{pmatrix} \begin{pmatrix} j_d \\ j_q \end{pmatrix} + \begin{pmatrix} \omega L_d & 0 \\ 0 & \omega L_q \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

$$\frac{d}{dt} \begin{pmatrix} j_d \\ j_q \end{pmatrix} = \begin{pmatrix} -\omega d & 0 \\ 0 & -\omega d \end{pmatrix} \begin{pmatrix} j_d \\ j_q \end{pmatrix} + \begin{pmatrix} \omega d & 0 \\ 0 & \omega d \end{pmatrix} \begin{pmatrix} i_{dr} - i_d \\ i_{qr} - i_q \end{pmatrix}$$

wherein i_d is said d-axis current,

i_q is said q-axis current,

i_{dr} is said commanded d-axis current value,

i_{qr} is said commanded q-axis current value,

v_d is a d-axis voltage applied to the motor,

v_q is a q-axis voltage applied to the motor,

L_d is an inductance of the d-axis of the motor,

L_q is an inductance of the q-axis of the motor,

R is an electric resistance of the motor,

ω is an angular velocity of a rotor of the motor,

Φ is a number of magnetic cross fluxes of a permanent magnet of the motor,

j_d is a d-axis state quantity of said controller,

j_q is a q-axis state quantity of said controller, and

ω_d is a coefficient